CLAIMS

1. A screw driving device for performing a tightening operation and a loosening operation on a screw with respect to a screw hole that is correspondingly formed in a member to be fastened, comprising:

a device body in which are provided piezoelectric element that generates predetermined ultrasonic oscillations upon being impressed with a predetermined alternating current, and an oscillating end surface on which mechanical oscillations are excited based on the ultrasonic oscillations; and

an oscillation transmission means that is integrally fixed to the device body on the oscillating end surface and that transmits the mechanical oscillations to the screw by contact with the screw.

2. The screw driving device according to claim 1, wherein

the oscillation transmission means has a male distal end portion that is correspondingly formed to be capable of fitting in a female recess formed in a screw head of the screw, and that imparts running torque by external force and transmits mechanical oscillations in a predetermined direction that the device body excites to the screw with which contact is made by fitting in the female recess.

3. The screw driving device according to claim 1, wherein

the piezoelectric element comprises two types of piezoelectric element groups when the rotation axis in the rotation direction of a screw is set as a z-axis in an xyz orthogonal coordinate system, namely, pitch-direction flexural oscillation piezoelectric elements that excite pitch-direction flexural oscillation having a y-axis as a pitch axis, and roll-direction flexural oscillation piezoelectric elements that excite roll-direction flexural oscillation having an x-axis, which is perpendicular to the pitch axis, as a roll

axis.

4. The screw driving device according to claim 3, wherein

the device body is constituted to enable application of the predetermined AC voltage so that the flexural oscillation in a pitch direction to be excited by the pitch direction flexural oscillation piezoelectric elements and the flexural oscillation in a roll direction to be excited by the roll direction flexural oscillation piezoelectric elements have a phase difference of 90º therebetween.

5. The screw driving device according to claim 4, wherein

the device body is a Langevin oscillator.

6. The screw driving device according to claim 4, wherein

the device body functions as a stator of a traveling-wave ultrasonic motor that generates traveling flexural elastic waves in the piezoelectric elements by application of the AC voltage and transmits the mechanical oscillations in a predetermined direction based on the traveling flexural elastic waves to the male distal end portion.

7. The screw driving device according to claim 1, wherein

the oscillation transmission means includes a frictional material that is provided with a screw contact surface that is correspondingly formed to be capable of surface contact with a top end face formed on the screw head of the screw to transmit ultrasonic mechanical oscillations to the screw by frictional contact with the top end face.

8. The screw driving device according to claim 7, wherein

the device body includes a preload generating means that generates a preload for steadily press-contacting the top end face of the screw head against the screw

contact surface of the frictional material.

9. The screw driving device according to claim 8, wherein

the preload generating means is embedded in a distal end oscillating member that constitutes the oscillating end surface of the device body, and

is a permanent magnet that generates magnetic force that attracts the screw head in a direction that presses the top end face of the screw against the screw contact surface incorporated with the rear face of the frictional material, or is a suction tube that passes through the device body for generating adsorption power which attracts the screw head by having a suction port face the center portion of the frictional material that is annularly shaped.

10. The screw driving device according to claim 8, wherein

in the case in which the screw has a relative length that exposes a screw distal end from a back of the member to be fastened in the process of being screwed in the screw hole, and the screw distal end has a distal end flat face that includes a plane element corresponding to the top end face of the screw head,

the preload generating means is a vise mechanism member that generates mechanical force that presses the distal end flat face of the screw distal end, which is in the state of being exposed from the back of the member to be fastened, in a direction of making the top end face of the screw head press against the screw contact surface of the frictional material, and

the vise mechanism member includes a preload transmission shaft that joins to freely interlock integrally with axial rotational motion that is transmitted to the screw via the frictional material from the device body while pressing the distal end flat face of the screw distal end with the mechanical force, and

a ball bearing set that fittingly holds with shaft bearings the preload transmission

shaft in a manner allowing it to spin freely.

11. The screw driving device according to claim 8, wherein

in the case in which the screw has a relative length that exposes the screw distal end from the back of the member to be fastened in the process of being screwed in the screw hole, and the screw distal end has a distal end flat face that includes a plane element corresponding to the top end face of the screw head,

the preload generating means includes a second device body constituted by stacking a plurality of piezoelectric elements so that accompanying the application of an AC voltage to the plurality of piezoelectric elements ultrasonic oscillations are generated that can make the distal end flat face of the screw distal end in contact with the oscillating end surface thereof perform axial rotational motion, and

a flat, disc-shaped second frictional material that is adhered to the oscillating end surface of the second device body and transmit the axial rotational motion accompanying the ultrasonic oscillations to the screw by making frictional contact with the distal end flat face of the screw distal end,

with the second device body is positioned with its axial center aligned so that the axial rotational motion that is transmitted to the screw via the frictional material from the device body and the axial rotational motion that is transmitted to the screw via the second frictional material perform coaxial rotation when positioned to be capable of pressing via the second frictional material the distal end flat face of the screw distal end, which is in the state of being exposed from the back of the member to be fastened in a positional relation with the device body of facing each other while sandwiching the screw and the screw hole therebetween.

12. The screw driving device according to claim 10, wherein the vise mechanism member includes,

in place of the preload transmission shaft and the ball bearing set,

a second device body constituted by stacking a plurality of piezoelectric elements so that accompanying the application of an AC voltage to the plurality of piezoelectric elements ultrasonic oscillations are generated that can make the distal end flat face of the screw distal end in contact with the oscillating end surface thereof perform axial rotational motion,

a flat, disc-shaped second frictional material that is adhered to the oscillating end surface of the second device body and transmits the axial rotational motion accompanying the ultrasonic oscillations to the screw by making frictional contact with the distal end flat face of the screw distal end, and

the second device body is positioned with its axial center aligned so that the axial rotational motion that is transmitted to the screw via the frictional material from the device body and the axial rotational motion that is transmitted to the screw via the second frictional material perform coaxial rotation when pressing the distal end flat face of the screw distal end by the mechanical force generated by the vise mechanism member.

13. The screw driving device according to claim 7, wherein

the device body, in its positional relation with the member to be fastened, has the screw contact surface of the frictional material positionally arranged to freely maintain a permanent contact state with the top end face of the screw head even after completion of the fastening operating of the screw with respect to the screw hole.

14. The screw driving device according to claim 13, wherein

the device body includes a laser range finder that periodically measures by a laser beam the distance between a range-finder reference point provided on the device body and the fastened body, wherein

the laser range finder is constituted to automatically instruct the corresponding plurality of piezoelectric elements to start application control of the AC voltage for generating the ultrasonic oscillations that perform the fastening operation of the screw when loosening of the screw is detected by the measured distance exceeding a predetermined value.

15. The screw driving device according to claim 1, wherein

the device body is constituted to form a cylinder with a center hole by integrally stacking a plurality of piezoelectric elements that form an annular shape has a center hole and a flange member that projects a guard portion further to the outer circumference than the piezoelectric elements at a non-oscillating region among oscillations that the plurality of piezoelectric elements excite and through which a center hole is formed for securing that position and, accompanying the application of AC voltage to the plurality of piezoelectric elements, generating ultrasonic oscillations capable of transmitting an axial rotational motion to the top end face of the screw head in contact with the oscillating end surface,

the oscillation transmission means includes a frictional material that is provided with a screw contact surface that is correspondingly formed to be surface contactable with the top end face formed on the screw head of the screw to transmit ultrasonic mechanical oscillations to the screw by making frictional contact with the top end face, and

the oscillation transmission means further includes

a screw driving device-side hook that is connected to the distal end of a wire that is inserted in the center hole of the device body and constituted to be capable of engaging with a screw-side engaging portion that is provided in a protruding manner on the top end face of the screw,

a preload generating means that tensions the screw driving device-side hook via

the wire to generate a preload force for steadily press-contacting the oscillating end surface of the device body and the top end face of the screw head, and

a preload generating means fixing member that faces a vicinity further to the rear of the rear end surface of the device body opposite the oscillating end surface, and secures the preload generating means while facing the flange member.

16. The screw driving device according to claim 15, wherein

the preload generating means fixing member is constituted by coupling a pin shaft end that is movably supported to spin freely in bearings provided in the center and a wire end that rotates in conjunction with the axial rotational motion of the screw that is transmitted by the screw driving device-side hook.

17. A screw driving device according to claim 15, wherein

the preload generating means is a compressive elastic body group that continuously presses the oscillating end surface of the device body to make contact with the top end face of the screw head by being tautly stretched in parallel between symmetrical sections of the guard portion of the flange member and sections of the preload generating means fixing member opposite the guard portion with the device body placed therebetween to apply the compressive elastic force to the flange member and to the preload generating means fixing member.

18. The screw driving device according to claim 15, comprising

a frame-type elastic body fixing member that contains the device body together with the preload generating means fixing member in a state of exposing the oscillating end surface to the outside, with both ends thereof is fixed to opposite ends of the guard portion of the flange member, wherein

the preload generating means is a tensile elastic body group that continuously

presses the oscillating end surface of the device body to make contact with the top end face of the screw head by being tautly stretched in parallel between the preload generating means fixing member and sections of the elastic body fixing member that face symmetrical sections of the preload generating means fixing member.

19. The screw driving device according to claim 15, wherein

the preload generating means is a tensile elastic body that presses the oscillating end surface of the device body to make contact with the top end face of the screw head by being tautly stretched to interpose between the wire and the preload generating means fixing member to apply a tensile elastic force to the wire and the preload generating means fixing member.

20. The screw driving device according to claim 15, comprising

stoppers that are adjustably constituted so as to generate the preload force on the oscillating end surface of the device body and the top end face of the screw head, the stoppers spanning between the guard portion of the flange member and the sections of the preload generating means fixing member facing the guard portion, with one end thereof is openably and closably hinged via a hinge, and a claw portion at the other end detachably engaging with the outside edge of the preload generating means fixing member that is faced, and so when hitching and unhitching the screw driving device-side hook that projects from the center hole of the oscillating end surface with respect to the screw-side engaging portion in the engaged state, by fixing the gap between the guard portion of the flange member and the preload generating means fixing member to a predetermined gap in opposition to the preload force generated in the preload generating means, the oscillating end surface of the device body and the top end face of the screw head are spaced apart, releasing the preload force imparted to the oscillating end surface of the device body and the top end face of the screw head, and on the other

hand when releasing the engagement of the claw portions, the preload force is applied, which spaces out the gap to be greater than the predetermined gap, whereby the oscillating end surface of the device body and the top end face of the screw head are brought into contact.

21. The screw driving device according to claim 15, comprising

vise mechanism members that press symmetrical sections of the guard portion of the flange member and sections of the preload generating means fixing member opposite the guard portion by being interposed therebetween so as to freely move them closer or farther apart and generate an adjustable mechanical force in a given gap between the guard portion of the flange member and the preload generating means fixing member in opposition to the preload force generated in the preload generating means, is adjustably constituted to generate the preload force of the desired magnitude on the oscillating end surface of the device body and the top end face of the screw head.

22. The screw driving device according to claim 15, wherein

the preload generating means fixing member is a U-shaped frame body has both ends fixed to symmetrical sections of the guard portion of the flange member so as to contain at least the rear portion of the device body, and

the preload generating means is a direct-acting actuator that generates a predetermined tension in a linear direction in the wire, is installed on the preload generating means fixing member on the center hole cylindrical extension of the device body further to the rear of the rear end surface of the device body.

23. The screw driving device according to claim 15, wherein

the device body has a magnet that is embedded in a distal end oscillating member that constitutes the oscillating end surface of the device body and that

generates magnetic force that attracts the screw head in a direction that press-contacts the top end face of the screw head on the oscillating end surface.

24. A screw corresponding to the screw driving device as claimed in claim 7, wherein

the top end face of the screw head has a flat surface that includes only of a disc-shaped flat element without a "+" or "-" recess corresponding to the frictional material of the screw driving device, and

the top portion circumferential side portion of the screw head has a circumferential side surface including only of a circular surface element.

25. A screw corresponding to the screw driving device as claimed in claim 15, wherein

the top end face of the screw head is formed as a circular flat surface without a female recess that correspondingly fits the distal end of the screw driving device, and

providing in a protruding manner on the circular flat surface a screw-side engaging portion that is capable of engaging with the screw driving device-side hook.

26. The screw according to claim 25, wherein

the screw-side engaging portion is constituted to be able to be cut off so that after screwing in the screw, the top end face of the screw head becomes a circular flat surface.

27. A screw corresponding to the screw driving device as claimed in claim 1, in which a screw-threaded shaft that is made to protrudingly stand on the center of the seating surface of the screw head is screwed into a screw hole that is correspondingly formed in the member to be fastened, and after is once fastened to the screw hole, enhances the fastening force by increasing the pressing force that acts between the seating surface of the screw head and the member to be fastened, comprising:

a washer that exerts the fastening force of the screw by being mounted on the screw-threaded shaft to make contact with the circumferential edge of the screw hole when the screw is fastened to the member to be fastened; and

an elastic force generating means that applies an elastic force that expands the space between the screw head and the washer to increase the pressing force of the washer to the member to be fastened.

28. The screw according to claim 27, comprising

an elastic force restraining means that is constituted to fix in a predetermined gap the elastic force generating means in a pre-compressed state by forcibly applying to the seating surface of the screw head and the end face of the washer facing opposite a restraining force that opposes the elastic force of the elastic force generating means, and when the application of the restraining force is released after fastening to the screw hole, the elastic force restraining means is capable of releasing the elastic force of the elastic force generating means.

29. The screw according to claim 28, wherein

the elastic force restraining means is an adhesive that sets to adhesively fix the elastic force generating means in a compressed state so as to bring the seating surface of the screw head and the end face of the washer facing opposite closer together until a predetermined gap, and is capable of releasing the elastic force of the elastic force generating means by releasing the adhesive fixation when a predetermined process is performed.

30. The screw according to claim 28, wherein

the screw-threaded shaft annularly projecting a water ingress prevention means that seals a gap between the screw-threaded shaft and the screw hole so that, when a

predetermined releasing means is applied to release the application of the restraining force of the elastic force restraining means, ingress of water of the releasing means is prevented from entering the screw hole.

31. The screw according to claim 27, wherein

the elastic force generating means includes a compression coil spring that is constituted by an elastic member, that revolves spirally centered on the neck end portion of the screw-threaded shaft and is interposed between the seating surface of the screw head and the end face of the washer facing opposite.

32. The screw according to claim 27, wherein

the washer and the elastic force generating means is integrally formed by a spring washer.

33. The screw according to claim 27, wherein

the top end face of the screw head is formed as a flat surface without a female recess that correspondingly fits the oscillation transmission means of the screw driving device.